



Original communication

Fatal ethyl and methyl alcohol-related poisoning in Ankara: A retrospective analysis of 10,720 cases between 2001 and 2011

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ARTICLE INFO

Article history:

Received 8 March 2012

Received in revised form

21 April 2012

Accepted 29 May 2012

Available online 15 July 2012

Keywords:

Ethanol

Methanol

Poisoning

Forensic

Intoxication

ABSTRACT

Methyl and ethyl alcohol poisoning are still responsible for high morbidity and mortality rates. The purpose of this retrospective study was to examine ethyl and methyl alcohol poisoning related deaths in Ankara and surrounding cities between 2001 and 2011 and compare them with previous studied conducted in Turkey and other countries. For this purpose, 10,720 medico-legal autopsy cases performed in Ankara Branch of the Council of Forensic Medicine were reviewed in terms of alcohol poisonings.

The deaths due to methanol and ethanol poisoning were 74 (0.69% of all medico-legal autopsies performed) and the distribution among them was 35 (47.3%) for methanol poisoning and 39 (52.7%) for ethanol poisoning. Overwhelming majority of the cases were male ($n = 67$, 90.5%). The mean age of the victims was 44.9 ± 10.9 years and ranging from 21 to 92 years. The age group of 35–49 years was the mostly affected. Most of the cases were seen in 2004 ($n = 12$, 16.2%). The levels of postmortem blood alcohol levels were available for all cases and the mean alcohol levels were 322.8 ± 155.5 mg/dL ranging from 74 to 602 mg/dL for methanol and 396.8 ± 87.1 mg/dL and ranging from 136 to 608 mg/dL for ethanol.

Early diagnosis is essential for successful treatment in methanol and ethanol poisoning. Besides increased awareness, more sensitive/specific diagnostic tools, and the prompt approach to the poisoned individual should be implemented in the hospitals.

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1. Introduction

Ethyl and methyl alcohols are widely available in household and commercial products that are intentionally abused or unintentionally exposed.^{1,2} Methanol is sometimes abused as ethanol substitutes. Because of the wide availability of these alcohols and the potential toxicity, people should be alerted about the harmful effects of the products that contain ethyl and methyl alcohols.

Methanol (CH₃OH, wood alcohol) poisoning is a life-threatening event that leads severe metabolic disturbances, neurological

dysfunction, blindness, and even death. It is easily and rapidly absorbed throughout the digestive system, and even through inhalation and skin absorption.³ Clinical symptoms of ethanol and methanol poisonings are partly similar and nonspecific. These symptoms include vomiting, seizures, slow and irregular breathing, confusion, stupor, hypothermia, unconsciousness, and even coma. The poisoning may be mislead by the situations including diabetic ketoacidosis, pancreatitis, meningitis, and several other diseases.⁴ In case of methanol poisoning; supportive care, infusion of sodium bicarbonate (for acidosis), antidotes (competitive ADH substrates such as ethanol⁵), inhibitors of ADH metabolism of methanol, intermittent dialysis are recommended managements.^{6,7}

Severe methanol poisoning is not rare in Turkey even if there is no traditional culture of distilling alcohol at home. Outbreaks of methanol poisonings, caused by illegally produced alcohol, have

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been reported. Main source for methanol in these cases was the product of “eu de colognes” manufactured from cheap methanol rather than relatively expensive ethanol. People are intoxicated by drinking unregistered illegally bought industrial beverages in Turkey.⁸ In a 9-year follow-up study showing the data of Drug and Poison Information Center in Turkey, it was reported that 16 patients died, 63 patients completely recovered, and one patient had irreversible blindness in that time interval (1993–2002).⁹ Ankara is the capital city of Turkey, having an estimated population of about 5 million people. Ankara Branch of the Council of Forensic Medicine accepts the medico-legal deaths for autopsy from all surrounding 20 cities. Therefore, our institution is responsible for performing medico-legal autopsies much more than 5 million people living in surrounding area. The aim of this study was to characterize methanol and ethanol poisoning cases within the medico-legal autopsies carried out in Ankara Branch of the Council of Forensic Medicine. We have also accepted blood and other biological materials for toxicological analyses from several surrounding institutes and hospitals that have authority to perform autopsies in those areas.

2. Materials and methods

Retrospective data was obtained from Ankara Branch of the Council of Forensic Medicine database of alcohol poisonings between the years 2001 and 2011 (screening for 11 year). The alcohol poisoning cases were analyzed using multi-parametric criteria such as age, gender, and the year of the death. All recorded cases of ethyl and methyl alcohol poisoning during the study period were included in the study. Many of the complete autopsies with full examination were performed in the morgue section of Ankara Branch of the Council of Forensic Medicine. Common specimens were submitted to the Chemistry Department for testing including femoral and hearth blood, urine, gastric content, some organs, and in some cases, other biological materials like vitreous humor. As a recent application, sodium fluoride was previously added to the blood tubes as a preservative agent against internal alcohol production by microorganisms. If the autopsy was performed by other places rather than our morgue department, they sent the biological specimen to the Chemistry Department to be tested for systematic toxicological analyses. The samples were stored at approximately 4 °C after arrival in the laboratory. The methyl and ethyl alcohol analyses were performed in the Chemistry Department by headspace gas chromatography (PerkinElmer Clarus 500) equipped with dual columns and flame ionization detector using n-propanol as an internal standard. The method is standardized in terms of limit of detection (LOD), limit of quantitation (LOQ), and linearity up to 1000 mg/dL. It was a volatiles screen method that simultaneously detects and quantifies ethyl alcohol, methyl alcohol, isopropanol, and acetone. As a detection condition, nitrogen gas (30 psi) was used as carrier; the oven temperature was programmed at 40 °C during 8-min analysis per sample. The temperatures of headspace unit were as follows: injector 75 °C and transfer line column 150 °C, while the vial holder was adjusted to 70 °C.

The background information about the cases was available for each case using the sources including police reports, sometimes hospital case notes and autopsy notes. Scrutiny of these data allowed a judgment to be made as suicides, accident or homicide for the cases. The medical examiners working in our institution reach a decision regarding manner of death after gathering information from the related sections like toxicology and narcotics of Chemistry Department.

This study was approved by ethical committee of the Council of Forensic Medicine upon application by the authors. The Statistical

Package for Social Sciences (SPSS) version 16.0 was used to analyze the data. The statistical test for comparison used was Chi-square test. This test was performed to compare actual frequency counts against the null hypothesis for bivariate tabular analyses.

3. Results

The results regarding ethanol and methanol poisonings in Ankara are shown in Tables 1–4. The total number of medico-legal autopsies was 10,720, during the period of the study. The deaths due to methanol and ethanol poisoning were 74 (0.69% of all medico-legal autopsies performed) and of these 35 (47.3%) were methanol poisoning and 39 (52.7%) were ethanol poisoning. Overwhelming majority of the cases were male ($n = 67$, 90.5%) with a mean age of 44.9 ± 10.9 years (ages ranged between 21 and 92 years). The age group 35–49 years was the mostly affected. Most of the cases were seen in 2004 ($n = 12$, 16.2%) followed by 2002 ($n = 11$, 14.9%), and 2003 and 2001 ($n = 10$, 13.5% in both). In 31 cases, only ethyl alcohol was found in postmortem blood specimens while only methyl alcohol was found in 27 cases. Different combinations of detected chemicals was found in the rest of the cases such as ethyl alcohol and carbon monoxide (CO) ($n = 2$), methyl alcohol and CO ($n = 2$), ethyl alcohol and medical drugs ($n = 5$), and methyl alcohol and medical drugs ($n = 4$). Both ethyl and methyl alcohols were detected together, in only one case. The levels of postmortem blood alcohol levels were available for all cases and the mean alcohol levels were 322.8 ± 155.5 mg/dL ranging from 74 to 602 mg/dL for methanol and 396.8 ± 87.1 mg/dL and ranging from 136 to 608 mg/dL for ethanol. After grouping the cases according to their origin province, the most cases were from the capital city of Turkey, Ankara ($n = 48$, 64.9%) followed by Corum ($n = 5$, 6.8%), Kirikkale ($n = 4$, 5.4%), and Yozgat ($n = 4$, 5.4%).

4. Discussion

A total of 74 deaths due to ethyl and methyl alcohol represented 0.69% of all medico-legal autopsies performed at forensic medicine departments during 11 years (total 10,720 autopsies). The percentage of ethyl and methyl poisonings within total fatal poisoning cases was 11.9% (74 cases out of 622 fatal poisonings). Yearly distribution and percentage of alcohol poisoning showed that the highest number of deaths was seen in 2004. The highest number of poisonings due to alcohol was seen in the city of Ankara ($n = 48$, 64.9%) followed by Corum ($n = 5$, 6.8%) and the other cities, which indicates a great difference between case numbers from Ankara and the other cities in which the alcohol-related deaths were seen.

In most of the cases, we were unable to reach the information about manner of death whether it is a homicide or suicide in the light of the available records. There was no incident of suicides by ethyl and methyl alcohol poisonings. The blood alcohol concentrations encountered in deceased were consistent with toxic and fatal ranges. Methanol blood levels peak at approximately 30–60 min after ingestion. For social-type drinking, the highest blood ethanol concentration is usually achieved with the same time interval like methanol. In case of large amount of alcohol consumption over a short time interval, the absorption phase may

Table 1

The frequency and percentage of alcohol poisonings between years 2001 and 2011 in Ankara.

	Frequency	Percent	Mean age (year)	Std. dev.
Ethyl alcohol	39	52.7	45.4	11.9
Methyl alcohol	35	47.3	44.3	9.9
Total	74	100.0	44.9	10.9

Table 2

The gender distribution and percentage of all autopsied alcohol poisoning cases.

	Frequency	Percent	Mean age (year)	Std. dev.
Male	67	90.5	45.7	10.7
Female	7	9.5	36.3	10.9
Total	74	100.0	44.9	10.9

not be completed for up to 2 h after last consumption. The elimination occurs at a constant rate in the range of 10–20 mg% per hour. If we estimate roughly time interval of the medical treatment attempts to the cases and the autopsy time in our study, we can say that the real blood alcohol concentrations are higher than those of we detected.

Severe methanol intoxication is life-threatening, even ingestion of a small amount of it can be potentially lethal. Though methyl alcohol itself is not very poisonous, the by-products or degradation products are extremely harmful. It is transported to the liver where it is rapidly metabolized. Reactive oxygen species (ROS) are generated during methanol- and ethanol-induced liver injury. The effects of methanol poisoning on protein oxidation in the liver of rats were investigated by the researchers. They suggested that the increase in ROS generation and formaldehyde formation due to methanol poisoning lead to changes in molecular structure of many important proteins, and the observed effects on their physicochemical a biological activities may result in deleterious effects on liver function.¹⁰ In a clinical toxicology study, out of 276 patients admitted to emergency clinic, the overall case fatality rate was 1.4% and the most responsible agent for the death was ethyl alcohol (50%) followed by CO (25%) and organophosphate (25%) and half of the deaths were due to suicides.¹¹ Total of 27 alcohol poisoning cases (22 cases due to ethanol and 7 cases due to methanol) were detected at the Tongji Forensic Medical Center in Hubei, China during 1990–2008.¹² The maximum and minimum blood ethanol concentrations were 656.7 mg/dL and 326.0 mg/dL. The upper limit of methanol is pretty similar to that of our cases' limit.

The most lately paper about methanol poisoning in Turkey (the province Trabzon) was published by Birincioglu et al.¹³ A total of 4492 medico-legal autopsies were carried out in their morgue department. Among them, they reviewed the legal investigations and autopsy, toxicology, histopathology, and alcohol reports of 13 cases with methyl alcohol poisoning (0.3%) whose autopsies were carried out at Trabzon Branch of the Council of Forensic Medicine. They were all men aged between 25 and 44 years. The methyl alcohol levels of the blood of the victims were ranging between 15 and 482 mg/dL which is low compared to our limits. Eight cases had also ethyl alcohol in their blood ranging between 55 and 244 mg/dL. They reported that six cases consumed the famous alcoholic beverage Turkish Raki and five cases consumed cologne. The

Table 3

The detected chemicals in postmortem blood analyses of alcohol poisoning cases and their percentages.

	Frequency			Percent
	Male	Female	Total	
Ethyl alcohol	26	5	31	41.9
Methyl alcohol	26	1	27	36.5
Ethyl alcohol + CO	2	0	2	2.7
Ethyl alcohol + methyl alcohol + CO	1	0	1	1.4
Ethyl alcohol + burn	1	0	1	1.4
Methyl alcohol + CO	2	0	2	2.7
Methyl alcohol + medicine	3	1	4	5.4
Ethyl alcohol + medicine	5	0	5	6.8
Methyl alcohol + ethyl alcohol	1	0	1	1.4
Total	67	7	74	100

Table 4

The mean postmortem blood alcohol concentrations in autopsied cases. The numbers of cases seen here are those having only alcohol poisoning as reason of death.

	n	Minimum	Maximum	Mean	Std. deviation
Ethyl alcohol	31	136	608	396.8	87.1
Methyl alcohol	27	74	602	322.8	155.5

autopsy records of the Forensic Medicine Department of Trakya Medical Faculty between 1992 and 2003 showed that a total of 18 methanol related deaths (all males) were identified among 634 medico legal autopsies.¹⁴ In parallel with previous study, the investigators found the abnormal alcoholic beverages like False Raki from illicit sources and cologne as the consumed products. Among deaths of 229 homeless in Istanbul between 2000 and 2004, total of 91 (39.7%) cases was related to an unnatural event.¹⁵ The presence of alcohol was found to be significantly associated with the manner of death among them. Blood alcohol level over 50 mg/dL was determined in majority of unnatural death cases. This indirectly shows the primary cause of death as acute alcohol toxicity and drug-alcohol abuse among homeless people. In another study conducted in Turkey, ethyl alcohol was detected in 91 out of 761 hanging cases.¹⁶ The highest level of blood ethanol concentration was 421 mg/dL in a chronic alcoholic.

The percentage of mortality rate regarding ethanol is very high in our study compared to other studies conducted in different countries. The ethanol-based studies are mainly those of drug facilitated sexual assault (DFSA),^{17,18} suspected of driving under the influence (DUI) of ethanol,¹⁹ and road traffic suicides (accidents).^{20,21} Because of that, determination of blood alcohol concentration is needed in a multitude of situations, including in postmortem analysis, DFSA cases, DUI cases, workplace drug monitoring and probation investigations.²² The aim and the subject of the present study make it different from the others regarding fatal ethanol poisoning. When we compare ethanol and methanol as poisons, a major drawback is that ethanol may produce a central nervous system depression that is more pronounced than that produced by methanol. This may lead in some instances to respiratory depression requiring mechanical ventilation.⁵ In a study comparing all fatal alcohol poisonings in 1997 showed that in Finland the officially compiled statistics on fatal alcohol poisonings, when compared with medico-legal statements based on forensic toxicological examinations, were underrepresented by 31.7%.²³ Based on a medico-legal re-evaluation of death certificates, acute ethyl alcohol specific causes were found to be underreported nationally at a rate of 8% in Finland.²⁴ For alcohol poisoning alone, the figure was about 1%. This report supports our findings on high mortality rate due to ethyl alcohol in Ankara.

A few limitations need to be considered in the interpretation of our findings on ethanol poisoning: First, most of the cases of ethyl alcohol poisoning show no other reason for death in those people, so that the medical examiner gave a final decision on *mortis causa* as ethyl alcohol. Over the ten years period, ethyl alcohol topped the list of drugs identified in blood samples in single poisoning as well as in poly-drug-related deaths.²⁵ Second, as we know, drugs with similar mechanism of action, like ethanol and sedative-hypnotic drugs, make a dangerous combination. We are also supposed to think about the genotype of victims whether or not they are an ultra-rapid or a poor metabolizer via cytochrome p450 system enzymes in their liver and kidneys.²⁶ Another interpretation in postmortem toxicology for ethyl alcohol poisoning cases is most probably the suspected overdose death. On the other hand, the syndrome of alcoholic ketoacidosis is uncommon in patients with acute ethanol poisoning, being found in lesser than 10% of

patients.²⁷ It is most frequent in patients who have long-term ethanol intake and liver disease and develop the syndrome after a period of binge drinking.²⁸ These and some others²⁹ are real hypotheses that can explain the deaths after ethanol ingestion in our cases. Third, we determined methanol level in the postmortem blood samples by using headspace GC with FID detector and did not verify by another method. Direct detection of methanol usually requires a GC method, and such methods are not available in most hospitals. Another way of diagnosis for methanol poisoning is through measurement of serum formic acid.^{30,31} Formate concentration in blood or vitreous humor higher than 0.5 g/L is highly correlated with fatal outcome in methanol poisoning cases, unlike methanol concentrations alone. The presence of such an amount may indicate that the methanol was ingested during life, the methanol and formate were life-threatening, and the methanol detected was not present as an artifact or a mistake during specimen collection.³¹ The measurement of formic acid enzymatically is a fast and sensitive way of obtaining the methanol poisoning diagnosis. It is also easily adaptable to most auto-analyzers and requires only commercially available reagents. To be a referral laboratory, it can be used in both postmortem blood in forensic toxicology laboratories and live blood in hospital laboratories on 24 h basis to screen for poisoning of unknown agent.³⁰ Ethyl glucuronide and ethyl sulfate are other important markers of ethanol consumption (the product of liver degradation of ethanol) that needs to be detected to make sure that the toxicological analysis shows the real alcohol consumption but not an artifact coming from contamination during blood withdrawing process.³²

It was found that the concentration of alcohol and the type of beverage ingested affect the absorption rate of the alcohol. This could prove to be of considerable significance to the investigation in forensic medicine, especially the practice of retrograde extrapolation, used to estimate blood alcohol concentration at an earlier point in time.³

The alcohol users have been increasing dramatically in Turkey in recent years. In a statistical report prepared by Turkish Grand National Assembly (TBMM) and General Statistical Council of Turkey (TUIK), alcohol use by high school students within the last month (at least one time) was 16.5%. It is greater than the previous years' percentages. The risk of alcohol related deaths was noticed among adult males (45.4% for ethyl alcohol and 44.3% for methyl alcohol) in our study. However, fatal poisoning due to alcohol can be accepted as a moderate contribution to the deaths after CO poisoning, number one cause, in Turkey.

In conclusion, ethanol and methanol poisonings are among common and serious incidents. These are responsible for high mortality and morbidity rates because of delayed admission to the hospitals and late diagnosis. The numbers of the death due to alcohol is remarkably high compared to developed countries. This findings support the hypothesis that deaths due to ethyl and methyl alcohols is connected with prevailing intoxication-oriented drinking pattern, embitterment, illiteracy, and illegally produced harmful beverages. Further studies should be undertaken to elucidate all the aspects of the problem of alcohol poisoning and to address this problem on a national scale to obtain a comprehensive picture in Turkey.

Ethical approval

This study was approved by ethical committee of the Council of Forensic Medicine upon application by the authors.

Funding

None declared.

Conflict of interest

We all the authors disclose that there is no financial and personal relationships with other people or organizations that

could inappropriately influence (bias) our work. Examples of potential conflicts of interest include employment, consultancies, stock ownership, honoraria, paid expert testimony, patent applications/registrations, and grants or other funding. April 22, 2012.

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